The Problem with Relying on Technology[1,2]

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ABSTRACT. **This address will examine problems that arise when a society comes to rely on the technology of its time, and will provide support for this contention in the form of data we have recently collected about unintended effects of polychlorinated biphenyl (PCB). The reliance on technology results in the loss of previously accumulated knowledge because we cease to pass knowledge which has become "passé." Additionally the reliance on technology convinces the general public of our ability to do any task faster, better, bigger, and to the economic advantage of some. This situation began when early humans discovered that they could manipulate nature through the domestication of plants and animals, and has continued to the present time. The feeling that humans can better nature has led to short term benefits which are likely to become long-term detriments. Although the examples of such outcomes from reliance on technology are numerous, one that is currently being examined is the effect of environmental contamination by polychlorinated biphenyl (PCB), and the potential human health consequences of this contamination.**

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INTRODUCTION

It is my pleasure to share with you some ideas that have coalesced in my mind during 30-plus years (including graduate school) in the academic setting. I hasten to add that the opinions expressed here, and the metaphors chosen to illustrate them are those of the author, and do not represent a stance by the Ohio Academy of Science. These ideas have solidified with the continued input and stimulation of a number of students at various levels who have worked in my laboratory over the years, and of other colleagues, mentors, and significant others, who have had impact at various time points (Appendix I). Please note that the title of the presentation is not the problem with technology. Technology provides the cutting edge for scientific advancement, and its incorporation into our daily lives has been underestimated by better minds than the one with which I came equipped (Appendix II). As noted by the CEO of Intel, Andrew Grove, "Technology happens." It is when we become absolutely reliant upon technology that the problem arises.

This address will focus on the problems that arise when a society begins to rely absolutely upon the technology of its time. A current example will provide the opportunity to share with you some data regarding unanticipated effects of the entry of polychlorinated biphenyl (PCB) into the environment. I'll give away the punch lines right at the outset (then those of you with other things to concentrate on can tune out). There are at least two areas of concern when reliance on technology develops. First, we stop teaching and learning the information and procedures that were common knowledge before the advent of the technology. Second, the reliance on technology convinces the general public that it can have absolutely anything faster, better, bigger, and to the economic advantage of some.

At the outset

As far as can be determined, the difficulty began some 10,000 years ago in the Fertile Crescent area of what is now the Middle East when a group of hunter-gatherers discovered that they could domesticate, cultivate, and store grain, rather than leading a nomadic lifestyle. Domestication and employment of animals paralleled that of plants. Thus, these humans and their offspring discovered that they could manipulate nature, leading to the completely anthropocentric and haughty notion that they were above nature and, ultimately, that they could best nature in a fair fight. Of course, there were still natural occurrences which they did not understand, so they assigned these events to the control of an omnipotent God. So now our ancient ancestors had two ways to view their world. There were segments of nature which they

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[2]PRESIDENTIAL ADDRESS–Presented at the 107th Annual Meeting of The Ohio Academy of Science held at Miami University–Middletown Campus on 5 April 1998. Lee Meserve, Distinguished Teaching Professor of Biological Sciences, Bowling Green State University, has been a member of the Ohio Academy of Sciences for 24 years, Fellow since 1989, served *The Ohio Journal of Science* as Special Editor of the Abstracts Issue 1986-88 and as Editor 1989-95, was Vice President for Medical Sciences 1983-84 and 1988-89, and served on the Personnel Committee 1996. He has been the first author or co-author of at least one research presentation at each annual OAS meeting since joining in 1974. He and his wife Marge hold LIFE Family Membership in the Academy. Meserve received the BS degree in Animal Sciences from the University of Maine in 1966, and the PhD in Zoology (Endocrinology) from Rutgers University in 1972. He was Visiting Assistant Professor of Biology at Vassar College for one year, before coming to Bowling Green in 1973. At BGSU he has served the Department as Pre-Health Professions Advisor 1983-present and the University as Coordinator of the Pre-Physical Therapy Program 1980-89. He has Chaired the Radiation Safety Committee 1985-96, the United Way Steering Committee 1990-91, the Distinguished Teaching Professor Selection Committee 1994-96, and the Intercollegiate Athletics Committee 1996-98. He has served the profession as President of the BGSU Chapter of Sigma Xi 1983-84, 1995-96, Chair of the Endocrine Society Membership Committee 1993-96, and serves on the editorial boards of *Growth, Development & Aging* 1989-present and *Journal of Sex Research* 1992-present. He has published three book chapters and 28 papers in peer-reviewed journals, including four in *The Ohio Journal of Science*. He has received the Hollis A. Moore University Service Award 1990, the BGSU Master Teacher Award 1992, and a BGSU Distinguished Teaching Professorship 1993.

could manipulate and regulate themselves, and there were those which they could not manipulate which were overseen by God. And the more ambitious of our ancient ancestors strove for ways to extend their influence and understanding to areas of nature previously unavailable to their manipulation and regulation.

Of course with time there arose a group of our ancient ancestors who interpreted the acts and wishes of their God, and ultimately passed on the word of God, initially in the form of oral history. Eventually, written language developed, and the descendants of the oral historians became the "reporters" of God's word and God's wishes. And when written language developed, the descendants of these reporters recorded the word of God. For example:

> *"So God created man in his own image, in the image of God he created him: male and female he created them. And God blessed them, and God said unto them, Be fruitful and multiply, and replenish the earth and subdue it; and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."*
>
> Genesis 1:27-28.

And words of this sort were looked upon by the aforementioned ambitious ancient ancestors as direction by God to manipulate, to regulate, to pillage, and to plunder all natural components of the earth.

I am sure that each and every one of you has at one time or another been quoted out of context. This especially occurs if you have been quoted by a "reporter," who must fit your comments into a space requirement. Let's assume for a moment that God's reporters were quoting out of context. Let's assume that God, in Her infinite wisdom, provided additional marginal notes for the reporters. For example: "O.K., you've caught the gist of My meaning in the text, but I want it noted that I've provided ALL living things with this exquisite naturally balanced big blue marble, and I would prefer that it remain that way. So when you get to that 'be fruitful and multiply' line, please indicate that some degree of constraint should be exercised. Don't generate sufficient numbers of humans to force other fish, fowl, and living things off the earth. And by 'subduing' the earth and 'having dominion over it,' I more clearly mean that humans should accept stewardship for maintaining the balance that I have created." Unfortunately, the reporters had insufficient numbers of tablets of stone to accommodate God's marginal notes, so they read what they had originally written, found that it was good, and committed it to the ages. And the continuation of ambition has resulted in the assumption that humans are, in all cases, able to subdue or circumvent the natural order. [Note: Far be it from me to blaspheme and to attempt to augment or extend the word of God; nonetheless, I suspect that the original "reporters" were little different from those today.]

Time passes

Back to my original two punch lines. How is the reliance on technology likely to cause problems with regard to the elimination of "common knowledge" from our store of learning? It appears that Wendell Berry has caught the essence of this in a passage from his book *The Hidden Wood*:

> "The essential cultural discrimination is...between the superfluous and the indispensable... Granting the frailty, and no doubt the impermanence, of modern technology as a human contrivance, the man who can keep a fire in a stove or on a hearth is not only more durable, but wiser, closer to the meaning of fire, than the man who can only work a thermostat" (Berry 1989).

And do we see practical situations analogous to forgetting how to make and keep a fire? Certainly. An everyday example is the process of making change. Typically, individuals given the task of taking money for goods have come to rely on the electronic determination of what amount of change should be returned after a transaction. Go to a supermarket when the computer system is "down." Purchase goods worth $8.32. In an effort to minimize the volume of coins in your pocket, give the cashier eight one dollar bills, two quarters, and two pennies ($8.52). Watch them stare at you, and likely ask you to either give them exact change or nine one dollar bills so they can provide you with sixty-eight pennies!

An additional example of forgetting common knowledge has to do with the way that we, especially those of us in particularly affluent countries, interact with the weather. It would seem that we would all prefer the area in which we are located to have an ambient temperature between 20-25° C, little or no wind, and sunshine at all times. Just listen to the weather report on your local news. If there is likely to be rain on a weekend, it is frequently portrayed as a major disaster. If more than four inches of snow are likely to fall, schools are closed, special events are canceled, and the workforce is cautioned against venturing out of their domiciles. If the temperature falls below freezing, it is considered to be an unfair affront of the forces of nature! And how do we refer to violent weather? We revert to the second of our ancient ancestral world views and call them acts of God. There was a time when we could at least put up with the weather. If it rained, we wore appropriate clothing, carried an umbrella, or stayed inside. If it snowed a little, we proceeded with a bit more caution than if there were no snow, but we proceeded. If it were chilly, we donned more garments. We did not rail against our inability to control the weather. This is what we have become: "What is wrong with our technology!" we cry; "Not only can we not control the weather, we even predict it poorly." In fact, we should realize that there is much more of our natural world that falls into the category of that which we poorly (if ever) control. Much more.

Homocentrism

The other of my punch lines refers to reliance on technology convincing the general public that we can have anything faster, better, bigger, and at an economic advantage to some. For example, if we don't like the weather in northwest Ohio, we can jump on a plane to Jamaica. We don't have to walk to the east coast and take a sailing ship to reach this tropical paradise. We care

less at the moment that the products of combustion of petrochemical fuels, required for our translocation, are slowly (perhaps not so slowly anymore) upsetting the natural balance on that big blue marble.

NEW TECHNOLOGY: UNINTENDED CONSEQUENCES

I would feel that I had been remiss if I did not provide you with a bit of the data we have been collecting that fit into the picture I have been painting. Some of the molecules that humans have been able to synthesize through the efforts of technological advancement have not previously been part of the natural balance. Some of these molecules are halogenated hydrocarbons, examples being dioxin and polychlorinated biphenyls (PCB). PCB molecules fit into the "faster, better, bigger,..." scheme, by providing a number of advantages to the electrical, paint, and pesticide industries, to name but a few. They were first manufactured after the Second World War, and were widely used and widely discarded into the environment. It was felt that this was a safe way to go about disposal because PCB was not readily metabolized to anything else, and because it would only be discarded in small amounts. At the time, the concept of bioconcentration (accumulation of greater concentrations as a substance passes from prey organisms to predator organisms a number of times), and the details of physiological mechanisms working at very small concentrations of molecules (for example, nervous and endocrine systems) were poorly understood. So even though the production of PCB was prohibited by law in the 1970s, it is estimated that about one-third of that originally produced remains in the environment today.

Polychlorinated biphenyl and other organic substances are described as being environmental endocrine disrupters. Because of its structural similarity to thyroid hormones, PCB has been demonstrated to severely depress the level of thyroxine in the circulation of experimental rodents (and other species), either intentionally or accidentally ingesting the material (Byrne and others 1987). Since the research focus in our lab has been the investigation of developmental effects in young rats of subnormal thyroid status developed in their mothers during pregnancy (for example, Meserve and Leathem 1981, Meserve and Juárez de Ku 1993), we felt that extension of observations of the effects of PCB ingestion from adult animals to those occurring in young of pregnant rats would result in findings of particular interest to people in the area of the Great Lakes.

Our initial foray into investigation of the effects of PCB on neuroendocrine development used the fairly large doses of PCB (250 ppm) employed in studies with adult animals (Byrne and others 1987). Our demonstration of delayed development of a specific neuroendocrine axis (hypothalamus-pituitary-adrenal, HPA) by thiouracil-induced hypothyroidism had been found to be primarily at the level of the hypothalamus in 15-day-old rats (Meserve and Pearlmutter 1983). Maternal ingestion of PCB depressed circulating thyroxine concentration and also resulted in an alteration of HPA axis development, but the effects were more global, extending to the pituitary and adrenal, as well as the hypothalamus (Meserve and others 1992).

At this point, Linda Dokas, a friend and colleague at the Medical College of Ohio, suggested that we examine in the brains of these young rats, the activity of the enzyme choline acetyltransferase (ChAT). This enzyme is responsible for the synthesis of the neurotransmitter acetylcholine. She suggested this because other investigators had found its activity to be depressed in brains of young animals made hypothyroid with thiouracil (Patel and others 1987), and because brains of Alzheimer's patients have depressed activity of the enzyme in areas called the hippocampus and basal forebrain. Indeed, the activity of the enzyme was subnormal in these brain areas of our PCB-exposed young rats, in a dose dependent manner, and injection of thyroxine would bring them back toward normal (Juárez de Ku and others 1994). This led us to publish a paper touting these young animals to be a possible model for an Alzheimer's pathology, even though it was demonstrated in rats not yet weaned (Juárez de Ku and Meserve 1994)! Obviously it would be necessary to extend the PCB exposure to older animals to determine if this possible link to Alzheimer's had any real validity.

A subsequent study (Corey and others 1996) found that the ChAT activity in 60-day-old PCB-exposed animals was normal, sort of putting the kibosh on our suggested Alzheimer's connection...but not completely. These 60-day-old rats demonstrated subnormal learning and memory as measured by their ability to complete a radial arm maze task. So even though the ChAT activity was normal at this age (it appears to come back to normal considerably earlier than this; by 20 days of age as demonstrated by Pritts and others 1996), behavioral measures not dissimilar to those seen in early Alzheimer's disease persist. So is there a connection between Alzheimer's and PCB entry into the environ-ment or not? We still don't know, but the situation gets even scarier.

As mentioned earlier, the previously described studies fed quite large amounts of PCB to the pregnant rat, either 250 or 125 ppm by weight in the diet. It is unlikely that concentrations of these magnitudes would routinely be found in a food source, although recent studies of Lake Erie bald eagle eggs have found 60 ppm in the yolk. However, considerably less PCB has an effect on these parameters. As reported at the 1998 Ohio Academy meeting (Provost and others 1998), maternal dietary concentrations as low as 1.25 or 12.5 ppm cause measurable alterations of thyroid hormone and ChAT activity in 15- and 30-day-old rats, but behavior in a maze task does not appear to be altered. On the other hand, a specific molecular type of PCB (congener PCB 77) at the 12.5 ppm dietary concentration disrupts learning at 30 days of age, without a pronounced influence on thyroid status or ChAT activity (Ferlic and others 1998). These seemingly conflicting results require further investigation to allow appropriate evaluation. But I think you will agree that for a molecule that was supposed to supply only "faster, better, bigger..." results, with no down side, PCB (as well as many others) reinforces the problem of relying on technology.

CONCLUSIONS

While the members of the human species often feel that they can manipulate the natural scheme of things to their own advantage, there are many examples that indicate such a view is frequently a short-term gain. We often strive for the "quick fix" and the "easy way." In searching for the easy way we run into problems with my first punch line. We learn things that work perfectly well every time; then we find an easier way that has flaws and we forget the time-tested mechanism. That technology can provide such results faster, better, bigger, and to the economic advantage of some has been widely demonstrated in the short run. But as much as we know going in to technological advancements, they frequently have long-term, unforeseen down sides. Will it be possible for us to bail ourselves and our big blue marble out of these unintended down sides? Can we learn not to absolutely rely on technology?

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Appendix I

Students, mentors, and significant others.

Undergraduate Students

John Bondra
Tim Mislin
Tom Heringhaus
Babs (Surbeck) VanRenterghem
Chris Gaskins
Joel Yeasting
Teresa Single
Marcus Baratian
Ranni Amiri
Anton Woo
Elizabeth Jacobs
Kim (Rosiak) Seo
Joy Knight
Mary Bolin
Chad Zender
Marin Ferlic
Karissa Korpita

Masters Students

Fredica Robertson
Wayne Russell
Audrey (Rhodes) Boyd
Denise (Schulte) Knox
Patricia (Maiorca) Pascoe
Jonelle (Skibski) MacDonald
Arlene (Klak) Hall
Ron Cotter
Joe Scriffignano
Lyle Calcamuggio
Laura Juárez
Mary (Vicario) Smith
Ed McEwen
Mary Ann Gonzalez
Lillian Shaffer
Betty Murray
Jamie Landis
Diana Colon
Dave Albert
Monica (Sharma) Stokkermans
Ed Russ
Byung-Woun Seo
Deb Corey
Bill Noonan
Amy Pinney
Sachinder Vasudeva
Neil Shearing
Boyd Rorabaugh

Doctoral Students

Laura Juárez de Ku
Sundararajah Thevananther
Beth Pritts
Jamie Landis
Terri Provost

Mentors, Colleagues, Significant Others

Leslie Meserve
Ruth Meserve
William Hoover
Bruce Poulton
James Leathem
Marge (Jacko) Meserve
Joe Meites
Murray Saffran
Linda Dokas
Robert Sapolsky
David Suzuki

Appendix II

Predictions

"Computers in the future may weigh no more than 1.5 tons."
—Popular Mechanics, forecasting the relentless march of science, 1949.

"I think there is a world market for maybe five computers."
—Thomas Watson, chairman of IBM, 1943.

"I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won't last out the year."
—The editor in charge of business books for Prentice Hall,1957.

"But what...is it good for?"
—Engineer at the Advanced Computing Systems Division of IBM, 1968, commenting on the microchip.

"There is no reason anyone would want a computer in their home."
—Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977.

"This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us."
—Western Union internal memo, 1876.

"The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?"
—David Sarnoff's associates in response to his urgings for investment in the radio in the 1920s.

"The concept is interesting and well-formed, but in order to earn better than a 'C,' the idea must be feasible."
—A Yale University management professor in response to Fred Smith's paper proposing reliable overnight delivery service (Smith went on to found Federal Express Corp.).

"Who the hell wants to hear actors talk?"
—H.M. Warner, Warner Brothers, 1927.

"I'm just glad it'll be Clark Gable who's falling on his face and not Gary Cooper."
—Gary Cooper on his decision not to take the leading role in "Gone With The Wind."

"A cookie store is a bad idea. Besides, the market research reports say America likes crispy cookies, not soft and chewy cookies like you make."
—Response to Debbi Fields' idea of starting Mrs. Fields' Cookies.

"We don't like their sound, and guitar music is on the way out."
—Decca Recording Co. rejecting the Beatles, 1962.

"Heavier-than-air flying machines are impossible."
—Lord Kelvin, president, Royal Society, 1895.

"If I had thought about it, I wouldn't have done the experiment. The literature was full of examples that said you can't do this."
—Spencer Silver on the work that led to the unique adhesives for 3M "Post-It" Notepads.

"So we went to Atari and said, 'Hey, we've got this amazing thing, even built with some of your parts, and what do you think about funding us? Or we'll give it to you. We just want to do it. Pay our salary, we'll come work for you.' And they said, 'No.' So then we went to Hewlett-Packard, and they said, 'Hey, we don't need you. You haven't got through college yet.'"
—Apple Computer Inc. founder Steve Jobs on attempts to get Atari and HP interested in his and Steve Wozniak's personal computer.

"Professor Goddard does not know the relation between action and reaction and the need to have something better than a vacuum against which to react. He seems to lack the basic knowledge ladled out daily in high schools."
—1921 New York Times editorial about Robert Goddard's revolutionary rocket work.

"You want to have consistent and uniform muscle development across all of your muscles? It can't be done. It's just a fact of life. You just have to accept inconsistent muscle development as an unalterable condition of weight training."
—Response to Arthur Jones, who solved the "unsolvable" problem by inventing Nautilus.

"Drill for oil? You mean drill into the ground to try and find oil? You're crazy."
—Drillers who Edwin L. Drake tried to enlist to his project to drill for oil in 1859.

"Stocks have reached what looks like a permanently high plateau."
—Irving Fisher, Professor of Economics, Yale University, 1929.

"Airplanes are interesting toys but of no military value."
—Marechal Ferdinand Foch, Professor of Strategy, Ecole Superieure de Guerre.

"Everything that can be invented has been invented."
—Charles H. Duell, Commissioner, US Office of Patents, 1899.

"Louis Pasteur's theory of germs is ridiculous fiction."
—Pierre Pachet, Professor of Physiology at Toulouse, 1872.

"The abdomen, the chest, and the brain will forever be shut from the intrusion of the wise and humane surgeon."
—Sir John Eric Ericksen, British surgeon, appointed Surgeon Extraordinary to Queen Victoria 1873.

"640K ought to be enough for anybody."
—Bill Gates, 1981.